Transfer of Contaminants Between the Water Column and Bottom Sediments: The Role of Deposit- and Suspension-Feeding Benthic Invertebrates

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LONG-TERM GOAL

The ultimate goals of this research are to determine the dominant mechanisms whereby and the rates a which fine particles (<0.05 mm) are incorporated into marine sediments. Particular focus is on developing a mechanistic understanding of the role that deposit- and suspension-feeding benthic invertebrates play in particle deposition and burial relative to the abiotic case.

OBJECTIVES

The objectives of this project are to manipulate and test various combinations of hydrodynamic, sedimentological and biological parameters to determine the magnitude of: (1) net accumulation of fine particles in sandy and "reworked" (mixed grain size) sediments relative to muddy sediments, (2) biodeposition by suspension feeders relative to deposit feeders, and (3) vertical transport modes and rates of sediment transport within the bed by deposit feeders.

APPROACH

Carefully tailored laboratory flume and still-water experiments are used to quantify effects of suspension- and deposit-feeding benthic invertebrates on the transport of fine-grained sediment to the seabed, and its subsequent burial and retention within the bed. Using organisms from several functional and taxonomic groups, the flume and still-water studies are designed to determine the magnitude of biological effects (e.g., biodeposition, vertical transport in the bed, net accumulation) on fine-particle movement relative to the abiotic case. A variety of techniques are used to visualize and quantify flow and sediment transport, including digital particle image velocimetry (DPIV), optical backscatter sensors (OBSs), x-radiography and deliberate particle tracers. During FY98, we also sampled intertidal sediments to determine the vertical distribution of fine particles relative to the density of a surface deposit feeding worm (*Enoplobranchus sanguineus*) that was shown to subduct fine sediments in the lab.

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Aspects of this research are being conducted by J. Steven Fries as part of his dissertation research in the MIT/WHOI Joint Program. The goal of Fries's research is to determine the influence of the viscous sublayer on the deposition of particles to sand boundaries. The work is being conducted in a large, racetrack flume, recently constructed in WHOI's Coastal Research Center, and the techniques involve the use of DPIV to visualize and quantify the flow field, an array of OBSs to quantify fine particle transport, and direct sampling to measure fine-particle deposition.

WORK COMPLETED

During FY98, one manuscript (Fries et al., in press) was revised and accepted for publication. Steve Fries wrote and defended his dissertation research proposal, and began his thesis research. He also continued with the analysis of near-bed velocity field and bottom-stress measurements collected over and within animal-tube mimic arrays in flume flows.

New research conducted during FY98 focussed on improving understanding of the effects of a surface deposit-feeding polychaete on fine-particle subduction in intertidal sands. Our previous laboratory experiments with the terebellid polychaete, *Enoplobranchus sanguineus*, demonstrated that it can non-locally transport fine-grained sediment to depths of several centimeters in the seabed. A logical consequence of this activity is that areas supporting terrebellid populations should have a higher inventory of fine-grained sediments than areas without terrebellids. This species lives in sandy intertidal sediments where fine particles typically do not accumulate. Thus, significant subduction of fine particles by this species would have important sedimentological, ecological and applied implications.

RESULTS

During FY98, we sampled the vertical distribution of fine sediments in an intertidal sand flat with patchily distributed populations of *E. sanguineus*. One hundred cores were taken at low tide in Fairhaven Harbor, MA. There were 50 cores, one meter apart, along two perpendicular transect lines. The lines were oriented parallel and perpendicular to shore. Two types of cores were taken at each sampling location, a large-diameter core for enumeration of *E. sanguineus* individuals, and a small-diameter for quantification of the percentage of fine (<63 µm) sediments. The sediment cores were vertically sectioned into three depth horizons: 0-2, 2-6, and 6-10 cm. There was no significant trend in the percentage of fine sediments as a function of worm density for the upper two depth horizons, but for the 6-10 cm fraction the percentage of fine material increased with increasing worm density. Thus, these results support the *a priori* prediction that *E. sanguineus* subducts fine particles in sandy sediments.

As part of Fries' dissertation research, the fallout of fine suspended material was observed over boundaries of fixed sand roughness in a series of flume experiments. During these runs, particles collected in particle streaks usually associated with viscous sublayer flow structures over hydraulically smooth boundaries. The loss of material from suspension violated the anticipated balance between resuspension induced by bed shear stress and gravitational settling. This effective trapping of particles within the viscous sublayer will be studied in considerable detail.

IMPACT/IMPLICATIONS

In recent times, increasingly stricter regulations have been imposed on the discharge of toxic chemicals to harbors in order to improve water quality. Many of these chemicals adhere to and thus transport as fine particles. In determining sites and rates of toxic chemical accumulation, depositional (muddy) regions have had the greatest focus of attention because fine particles are not expected to be deposited or retained in erosion (sandy) locales. This research suggests, however, that bioturbating activities of sand-dwelling organisms can affect significantly the retention of fine particles in sands. Moreover, because horizontal fluid flux is higher in erosional as compared to depositional sites, sandy areas potentially are exposed to more (toxic-laden) mass per unit time than muddy areas.

TRANSITIONS

This research suggests that fine-particle accumulation should be studied in erosional, as well as depositional areas in order to understand the processes responsible for contaminant transport and retention in harbors associated with highly urbanized and industrialized cities.

RELATED PROJECTS

This project is part of the Harbor Processes research program and is related to other projects within this program that address biological effects on sediments and sediment transport (e.g., Linda Shafner, et al.).

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